**UAT-WP-4-07**
**01 May 2001**

# RTCA Special Committee 186, Working Group 5

## ADS-B UAT MOPS

## Meeting #4

# DRAFT 2 of Section 2.2 of the UAT MOPS

**(Presented by James Maynard)**


| SUMMARY |
| --- |
| The following represents a second draft of Section 2.2. This draft is based on Chris Moody's paper, UAT-WP-2-04, with additional text added to describe some of the ADS-B message payloads in more detail.<br><br>Note that I have described the Basic ADS-B message payload as having 18 bytes rather than 17. The additional byte seemed to be required to support the new NIC and NAC codes proposed for the new revised ADS-B MASPS, RTCA DO-242A. |

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# Draft #2 of the UAT MOPS Section 2.2
# 01 May 2001

Updated: Month day, year
RTCA/DO-???

Prepared by: RTCA, Inc.

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# 2.0 Equipment Performance Requirements and Test Procedures

## 2.1 General Requirements

## 2.2 Equipment Performance – Standard Conditions

### 2.2.1 Definition of Standard Conditions

#### 2.2.1.1 Signal Levels

Unless otherwise noted, the signal levels specified for transmitting devices in this subsection exist at the antenna end of a transmitter-to-antenna transmission line of loss equal to the maximum for which the transmitting function is designed.

Likewise, unless otherwise noted, the signal levels specified for receiving devices in this subsection exist at the antenna end of an antenna-to-receiver transmission line of loss equal to the maximum for which the receiving function is designed.

***NOTE:*** *Transmitting or receiving equipment may be installed with less than the designed maximum transmission line loss. Nevertheless, the standard conditions of this document are based on the maximum design value. Insertion losses internal to the antenna should be included as part of the net antenna gain.*

#### 2.2.1.2 Desired Signals

Unless otherwise specified, the desired signal specified as part of receiver performance requirements is any valid ADS-B Extended Type message.

### 2.2.2 ADS-B Transmitter Characteristics

#### 2.2.2.1 Transmission Frequency

The transmission frequency $f_0$ shall be [X] MHz +/- [20] PPM.

#### 2.2.2.2 Modulation Rate

The modulation rate shall be 1.041667 megabaud/second +/- [100] PPM. Each baud represents one bit. [However, receiver will have to have around a 20 PPM baud clock to demodulate the longer uplinks, so should we just make it 20 PPM?]

*NOTE: Ground Uplink Messages will use the same modulation type and rate. However, the rate tolerance for these messages will be +/- 10 PPM to support proper demodulation over their longer duration.*

*NOTE: Each baud represents one bit thus making each bit period 0.96 microsecond*

#### 2.2.2.3 Modulation Type

Data shall be modulated onto the carrier using binary Continuous Phase Frequency Shift Keying. The modulation index, *h*, shall be 0.6; this implies that if the data rate is $R_b$, then the nominal frequency separation between "mark" (binary 1) and "space" (binary 0) is $\Delta f = h \bullet R_b$. A binary 1 shall be indicated by a shift up in frequency from the nominal carrier frequency of $\Delta f/2$ (+312.5 kHz) and a binary 0 by a shift of $-\Delta f/2$ (-312.5 kHz). These frequency deviations shall apply at the optimum sampling points for the bit interval.

*NOTE: Filtration of the transmitted signal will be required to meet the spectral containment requirement of Section 2.2.2.5. This filtration will cause overshoot in the deviation, making the maximum deviation close to +/- 450 kHz at points outside the optimum sampling point.*

#### 2.2.2.4 Transmitter Power Output

##### 2.2.2.4.1 Minimum Power During the Active State

The minimum RF peak output power for each UAT equipment class shall be as given in Table 2-1.

##### 2.2.2.4.2 Maximum Power During the Active State

The maximum RF peak output power of each transmitted message at the terminals of the antenna shall be fixed at 160W for all classes of equipment.

### 2.2.2.4.3 Maximum Power During the Inactive State

When the transmitter is in the inactive state, the RF output power at the antenna terminals shall not exceed –80 dBm when measured at $f_0$ in a 1 MHz bandwidth.

*NOTE: The inactive state is defined to include all time other than the time required for ADS-B message transmission. ADS-B message transmission is inclusive of the time allowed for ramp up and ramp down intervals as defined in Section 2.2.3.1.*

*NOTE: This unwanted power requirement is necessary to ensure that the ADS-B transmitter does not prevent closely located UAT receiving equipment from meeting its requirements. It assumes that the isolation between transmitter and receiver equipment antenna exceeds 20 dB.*

### 2.2.2.5 Transmission Spectrum

[A spectrum mask specification is needed]

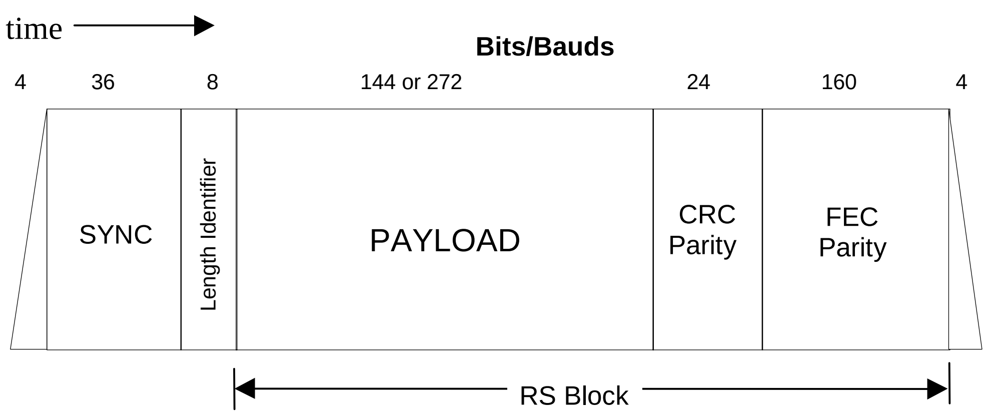
### 2.2.2.6 Spurious Emissions

[A specification is needed]

## 2.2.3 Broadcast Message Characteristics

### 2.2.3.1 ADS-B Message Format

The ADS-B Message format is shown in Figure 2-1. Each message element is described in detail in the subsections that follow.




**ADS-B Message Format**

#### 2.2.3.1.1 Ramp Up/Down

To minimize transient spectral components, the transmitter power shall ramp up and down at the start and end of each burst. The maximum time duration of these ramps shall be no more than 4 bit periods each. Ramp up time is defined as the time between the transmitter "off" level to 90% power output. Ramp down time is defined as the time to decay from full power to –80 dBm at the antenna terminals. During ramp up and down, the modulating data shall be all zeroes.

#### 2.2.3.1.2 Synchronization

Following ramp up, each data burst shall include a 36 bit synchronization sequence. For the ADS-B messages the sequence shall be

111010101100110111011010010011100010

with the left-most bit transmitted first.

#### 2.2.3.1.3 Length Identifier

[Is length identifier necessary? If so can it be reduced to something less than 8 bits?]

#### 2.2.3.1.4 Payload

The format and encoding of the ADS-B message payload is defined in Section 2.2.4.

#### 2.2.3.1.5 CRC Parity

[Is this even needed anymore with the new increased FEC proposal?]

#### 2.2.3.1.6 FEC Parity

[It would be good to assign this section to a R/S coding expert pending group decision on the waveform improvement subgroup]

### 2.2.3.2 Ground Uplink Message Format

[need figure and text to reflect group decision from waveform improvement subgroup]

### 2.2.3.2.1 Synchronization

The polarity of the bits of the synchronization sequence is reversed from that used for the ADS-B message, that is, the ones and zeroes are interchanged. This synchronization sequence is

000101010011001000100101101100011101

with the left-most bit transmitted first.

*NOTE: Because of the close relationship between the synchronization sequences used for the ADS-B and Ground Uplink Messages, the same correlator can search for both simultaneously.*

### 2.2.3.2.2 Payload

The Payload consists of two components: the UAT-Specific Header and the Application Data as shown in Figure X

Include Figure of Uplink Message Payload fields with the following:

-Header

--Gnd Station Lat

--Gnd Station Lon

--Time Slot assignment

--Flags for Position Valid, Time Valid, Use

-Application Data

#### 2.2.3.2.2.1 Header

#### 2.2.3.2.2.2 Application Data

[UAT MOPS should not define any format for application data in the uplink, but only packing and delimiting of Application Protocol Data Units]

### 2.2.3.2.3 FEC Parity Fields

[Need FEC expert input after waveform improvement decision]

### 2.2.4 The ADS-B Message Payload

#### 2.2.4.1 Basic ADS-B Message Format and Encoding

This subsection establishes the format and encoding of the Basic ADS-B Message Payload. Table 2-2 shows the overall format of the payload. Bytes and bits are transmitted in “big-endian” order; that is, the most significant byte is transmitted first, and within each byte, the most significant bit, bit #1, is transmitted first.

**Table 2-2. Format of Basic ADS-B Message Payload.**

| Byte # | Bit 1 | Bit 2 | Bit 3 | Bit 4 | Bit 5 | Bit 6 | Bit 7 | Bit 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | (MSB) | **Payload Type Code** | | (LSB) | (MSB) | **Address Qualifier** | | (LSB) |
| 2 | A1 (MSB) | A2 | A3 | . . . | | | | |
| 3 | | | | **Aircraft Address** | | | | |
| 4 | | | | | . . . | A22 | A23 | A24 (LSB) |
| 5 | (MSB) | | | | | | | |
| 6 | | | | **Latitude (WGS-84)** | | | | |
| 7 | | | | | | | (LSB) | (MSB) |
| 8 | | | | | | | | |
| 9 | | | | **Longitude (WGS-84)** | | | | |
| 10 | | | | | | | (LSB) | **P Valid** |
| 11 | (MSB) | **NIC** | | (LSB) | (MSB) | **$NAC_P$** | | (LSB) |
| 12 | **Turn Indicator** | | **Air/Ground State** | | (MSB) | | | |
| 13 | | | | **North Velocity or Ground Speed** | | | (LSB) | (MSB) |
| 14 | | | | **East Velocity or Heading** | | | | |
| 15 | | (LSB) | (MSB) | | **Pressure Altitude** | | | |
| 16 | | | (LSB) | | | | Status | (MSB) |
| 17 | | | **Pressure Altitude Rate** | | | | | (LSB) |
| 18 | (MSB) | **$NAC_V$** | | (LSB) | **T Valid** | **Q** | **Integrity Level** | |

The 18-byte basic payload format is also used for the first 18 bytes of long ADS-B messages (sections 2.2.4.2 and 2.2.4.3)

#### 2.2.4.1.1 Payload Type Code

The payload type code indicates whether the AD-B message is a basic ADS-B message (18-byte payload) or a long message (34-byte-payload). In the case of a long message, the payload type indicates what type of long message.

**Table 2-3. Payload Type Codes.**

| Payload Type Code | Message Type |
|---|---|
| 0 | Basic ADS-B Message |
| 1 | Long Type 1 ADS-B Message |
| 2 | Long Type 2 ADS-B Message |
| 3-11 | Reserved for other long ADS-B message types |
| 12-15 | Reserved for other uses |

Payload types 0 to 11 are reserved for ADS-B messages. Message type 0 indicates the basic ADS-B message payload of 18 bytes carrying basic ADS-B SV (State Vector) information. Message types 1 through 11 indicate long ADS-B messages, in which the first 18 bytes have the same structure as message type 0, carrying SV information. In these message types, bytes 19 through 34 contain other ADS-B information in addition to the basic SV information

Message types 12 to 15 are reserved for future definition. There is no assurance that messages of these types will carry SV information in their first 18 bytes.

#### 2.2.4.1.2 Address Qualifier

The Address Qualifier is a 4-bit field that indicates the type of address being communicated in the Aircraft Address field. The various Address Qualifier values are defined in Table 2-4 below.

**Table 2-4. Address Qualifier Codes.**

| Address Qualifier | Address Type |
|---|---|
| 0 | Own-ship ICAO 24-bit aircraft address |
| 1 | Own-ship random self-assigned “anonymous” address |
| 2 | ICAO 24-bit aircraft address of TIS-B target. |
| 3-15 | (Reserved) |

### 2.2.4.1.3 Aircraft Address

The meaning of the Aircraft Address field depends on the value of the AQ (Address Qualifier) field (section 2.2.4.1.2 ).

- If AQ=0, the Aircraft Address field holds the ICAO 24-bit address that has been assigned to the particular airframe.
- If AQ=1, the Aircraft Address field holds a random self-assigned own-ship "anonymous" address.
- If AQ=2, the message is a TIS-B message and the Aircraft Address field holds the ICAO 24-bit address that has been assigned to the target aircraft being described in the message.

### 2.2.4.1.4 Latitude

The Latitude field is a 23-bit field holding the aircraft/vehicle's WGS-84 latitude to a resolution of $2^{-24}$ circles (approximately 2.4 metres). It is formed by omitting the MSB of the 24-bit angular weighted binary numeral that represents the aircraft's latitude.

<u>Note 1</u>: *The "angular weighted binary" notation is a way of expressing angles as binary numerals in which the high-order bit has a weight of half a circle, or 180 degrees. In an N-bit angular weighted binary numeral, the LSB has a weight of $2^{-N}$ circles (360 degrees divided by $2^{N}$). An angular weighted binary numeral may be regarded <u>either</u> as an unsigned binary numeral in which the MSB has a weight of 180 degrees, <u>or</u> as a twos complement signed binary numeral, in which the MSB is the sign bit, and the next bit has a weight of 90 degrees (1/4 circle).*

<u>Note 2</u>: *For latitudes in the range [-90°, +90°), that is, from the S Pole almost to the N Pole, the 2 most-significant bits of the angular weighted binary numeral representing those latitudes will be identical. That is why the MSB may be omitted.*

<u>Note 3</u>: *When the 23-bit Latitude field is decoded in an ADS-B receiver, the report assembly function should reconstruct the full 24-bit angular weighted binary latitude from the 23-bit field in the message. This will involve some minimal tracking function, so that the N pole (angular weighted binary 0100 0000 0000 0000 0000 0000) is not mistaken for the S pole (angular weighted binary 1100 0000 0000 0000 0000 0000).*

### 2.2.4.1.5 Longitude

The Longitude field is a 24-bit field holding the aircraft/vehicle's WGS-84 longitude expressed in 24-bit angular weighted binary notation.

Note: *The "angular weighted binary" notation is a way of expressing angles as binary numerals in which the high-order bit has a weight of half a circle, or 180 degrees. In an N-bit angular weighted binary numeral, the LSB has a weight of $2^{-N}$ circles (360 degrees divided by $2^{N}$). An angular weighted binary numeral may be regarded either as an unsigned binary numeral in which the MSB has a weight of 180 degrees, or as a twos complement signed binary numeral, in which the MSB is the sign bit, and the next bit has a weight of 90 degrees (1/4 circle).*

### 2.2.4.1.6 P Valid (Position Valid) Flag

The Position Valid flag is a 1-bit field (byte #10, bit #8) indicating the validity of horizontal position given in the Latitude and Longitude fields. This bit shall be 1 if the position is valid, or 0 if the position is invalid. If the "P Valid" flag is 0, a receiving device should assume that the Latitude and Longitude fields do not contain meaningful horizontal position information.

### 2.2.4.1.7 NIC (Navigation Integrity Category)

The NIC (Navigation Integrity Category) is a 4-bit field (byte #11, bits 1-4) describing the integrity radius associated with the horizontal position information conveyed in the Latitude and Longitude fields. The various NIC codes are defined in ***draft*** RTCA DO-242A and reproduced in Table 2-5 below.

**Table 2-5. Navigation Integrity Category Codes.**

| NIC | Integrity Radius | Comment |
|---|---|---|
| 0 | Unknown | No Integrity |
| 1 | 20 nmi | RNP-10 containment radius |
| 2 | 8 nmi | RNP-4 containment radius |
| 3 | 4 nmi | RNP-2 containment radius |
| 4 | 2 nmi | RNP-1 containment radius |
| 5 | 0.6 nmi | RNP-0.3 containment radius |
| 6 | 0.2 nmi | |
| 7 | 0.1 nmi | |
| 8 | 75 m | |
| 9 | 25 m | |
| 10 | 7.5 m | |
| 11-15 | TBD | (Reserved for consecutively tighter containment radii.) |

The probability that the true position of the aircraft is outside the integrity radius announced in the NIC code without an "integrity alarm" occurring on board the transmitting aircraft is announced in the Integrity Level field (section 2.2.4.1.8).

### 2.2.4.1.8 Integrity Level

The Integrity Level is encoded in a 2-bit field (byte #18, bits 7-8). It indicates the level of confidence that may be placed on the position being within the integrity radius that is encoded in the NIC field. The various integrity levels are defined in Table 2-6 below.

**Table 2-6. Navigation Integrity Level Codes.**

| Integrity Level | Probability of Exceeding Integrity Radius Without An Integrity Alarm | Comment |
|---|---|---|
| 0 | Less than $10^{-5}$ per flight hour or per operation | |
| 1 | Less than $10^{-7}$ per flight hour or per operation | |
| 2 | (Reserved) | |
| 3 | (Reserved) | |

### 2.2.4.1.9 NACP

The $NAC_P$ field (Navigation Accuracy Category for Position) is a 4-bit field (byte #11, bits 5-8) describing the accuracy of the position information conveyed in the Latitude, Longitude fields and, for some $NAC_P$ codes, the geometric altitude field as well. The various NIC codes are defined in ***draft*** RTCA DO-242A and reproduced in Table 2-7 below.

**Table 2-7. Navigation Accuracy Category Codes.**

| $NAC_P$ | 95% Horizontal Accuracy Radius | 95% Vertical Accuracy Distance | Comment |
|---|---|---|---|
| 0 | ≥ 10 nmi | (Use pressure altitude,) | Unknown Accuracy |
| 1 | < 10 nmi | | RNP-10 Accuracy |
| 2 | < 4 nmi | | RNP-4 Accuracy |
| 3 | < 2 nmi | | RNP-2 Accuracy |
| 4 | < 1 nmi | | RNP-1 Accuracy |
| 5 | < 0.3 nmi | | RNP-0.3 Accuracy |
| 6 | < 0.1 nmi | | e.g., GPS-SPS with SA |
| 7 | < 0.05 nmi | | e.g., GPS-SPS with SA off |
| 8 | < 30 m | | |
| 9 | < 10 m | < 15 m | e.g., SBAS |
| 10 | < 3 m | < 4 m | e.g., WAAS |
| 11-15 | TBD | TBD | Reserved for successively tighter accuracy bounds. |

### 2.2.4.1.10 Turn Indicator

The Turn Indicator field is a 2-bit field (byte #12, bits 1-2) that indicates whether or the aircraft/vehicle is turning. The various Turn Indicator codes are defined in ***draft*** RTCA DO-242A and reproduced in Table 2-7 below.

**Table 2-7. Turn Indicator Values**

| Turn Indicator | Meaning |
|---|---|
| 0 | No Turn Information Available |
| 1 | Aircraft is NOT Turning at TBD degrees per second or more |
| 2 | Aircraft is Turning Right at TBD degrees per second or more |
| 3 | Aircraft is Turning Left at TBD degrees per second or more |

*<u>Note</u>: Various international and domestic committees responsible for establishing aviation related standards have not agreed upon the thresholds that should be used to determine whether an aircraft is turning. Until such time that firm agreement is reached and standards established, the conventions provided in the following paragraphs should be followed.*

*a. ADS-B transmitting devices shall set the Turn Indicator coding to **"0."***

*b. ADS-B receiving devices shall ignore all Turn Indicator codings other than **"0."***

*c. The ADS-B receiving devices shall set the Turn Indicator coding to **"0"** for all applicable cases until further definition is provided in this document.*

### 2.2.4.1.11 Air/Ground State

The Air/Ground State field is a 2-bit field (byte #17, bits 7-8) that indicates whether or not an aircraft is on the ground or airborne. The value of this field determines the encoding of "North Velocity or Ground Speed" and "East Velocity or Track Angle" fields. The possible field values are listed in <u>Table 2-8</u> below.

**<u>Table 2-8</u>. Air/Ground State Values.**

| **Air/Ground State** | **Byte #11** | | **Meaning** |
|---|---|---|---|
| | Bit 11 | Bit 12 | |
| 0 | 0 | 0 | Whether the aircraft is airborne or not is <u>unknown</u>. The horizontal velocity fields hold North Velocity and East Velocity to <u>0.5 knot</u> resolution. |
| 1 | 0 | 1 | The aircraft (or surface vehicle) is known to be <u>on the ground</u>. The horizontal velocity fields hold ground speed to <u>0.25 knot</u> resolution and Heading to $2^{-9}$ circle (about 0.7 degrees) resolution. |
| 2 | 1 | 0 | The aircraft is known to be airborne, with a speed of 1023 knots or less. The horizontal velocity fields hold North Velocity and East Velocity to <u>one knot</u> resolution. |
| 3 | 1 | 1 | The aircraft is known to be airborne, with a speed that may be in excess of 1024 knots. The horizontal velocity fields hold North Velocity and East Velocity to <u>4-knot</u> resolution. |

### 2.2.4.1.12 North Velocity or Ground Speed

The North Velocity or Ground Speed field is an 11-bit field (byte #12, bit #5 through byte #13, bit #7) for which the meaning is determined by the value of Air/Ground State field.

- If the Air/Ground State is 0, this field holds the N-S component of horizontal velocity, encoded as a signed twos complement binary numeral in which the LSB has a weight of 0.5 knot. The sign is positive for northward velocity, or negative for southward velocity.
- If the Air/Ground State is 1, this field holds the ground speed, encoded as an unsigned binary numeral in which the LSB has a weight of 0.25 knot.
- If the Air/Ground State is 2, this field holds the N-S component of horizontal velocity, encoded as a signed twos complement binary numeral in which the LSB has weight of 1 knot. The sign is positive for northward velocity, or negative for southward velocity.
- If the Air/Ground State is 3, this field holds the N-S component of horizontal velocity, encoded as a signed twos complement binary numeral in which the LSB has weight of 4 knots. The sign is positive for northward velocity, or negative for southward velocity.

### 2.2.4.1.13 East Velocity or Heading

The East Velocity or Track Angle field is an 11-bit field (byte #13, bit #8 through byte #15, bit #2) for which the meaning is determined by the value of the Air/Ground State field.

- If the Air/Ground State is 0, East Velocity or Heading field holds the E-W component of horizontal velocity, encoded as a signed twos complement binary numeral in which the LSB has a weight of 0.5 knot. The sign is positive for eastward velocity, or negative for westward velocity.
- If the Air/Ground State is 1, East Velocity or Heading field holds a “heading valid” flag, a “heading type” flag, and the aircraft’s heading, encoded as a 9-bit angular weight binary numeral.
    - The MSB of the 11-bit field (byte #13, bit #8) is the “heading valid” flag/ This bit is 1 if the aircraft’s heading is known, or 0 if the aircraft’s heading is not known.
    - The next bit (byte #14, bit #1) is 0 to indicate a true track angle, or 1 to indicate a magnetic track angle.
    - The remaining 9 bits (byte #14, bit #2 through byte #15, bit #2) hold the aircraft’s heading, expressed as a 9-bit angular weighted binary numeral.
- If the Air/Ground State is 2, East Velocity or Heading field holds the E-W component of horizontal velocity, encoded as a signed twos complement binary numeral in which the LSB has weight of 1 knot. The sign is positive for eastward velocity, or negative for westward velocity.

- If the Air/Ground State is 3, East Velocity or Heading field holds the E-W component of horizontal velocity, encoded as a signed twos complement binary numeral in which the LSB has weight of 4 knots. The sign is positive for eastward velocity, or negative for westward velocity.

### 2.2.4.1.14 Pressure Altitude

The Pressure Altitude field is a 12-bit field (byte #15, bit #3 through byte #16, bit #6) that encodes the aircraft's pressure altitude. The field is encoded as (altitude + 1000 feet) in 25-foot units. This permits pressure altitudes in the range from -1000 feet to more than +100 000 feet to be encoded in this 12-bit field. The "all ones" coding is reserved to mean "pressure altitude is unavailable."

```
0 0 0 0 0 0 0 0 0 0 0 0 = -1000 feet
0 0 0 0 0 0 0 0 0 0 0 1 =  -975 feet
. . .
0 0 0 0 0 0 0 0 0 1 1 1 =   -25 feet
0 0 0 0 0 0 1 0 1 0 0 0 =     0 feet
0 0 0 0 0 0 1 0 1 0 0 1 =   +25 feet
. . .
1 1 1 1 1 1 1 1 1 1 1 0 = +101350 feet
1 1 1 1 1 1 1 1 1 1 1 1 =   "invalid pressure altitude" or "pressure
                            altitude unknown"
```

### 2.2.4.1.15 "Q" (Altitude Quality) Field

The "Q" field (byte #18, bit #6) indicates the quality of the pressure altitude source. Q=0 indicates that altitude source only provides pressure altitude to a resolution of 100 feet. (For example, the altitude source might be a Gillham code altitude encoder.) Q=1 indicates that the altitude source provides pressure altitude to better than 100-foot resolution. (For example, the altitude source might be an ARINC 706 air data system.)

### 2.2.4.1.16 Pressure Altitude Rate

The Pressure Altitude Rate is encoded in a 10 bit field (byte #16, bit #7 through byte #17, bit #8). The altitude rate is encoded as a signed twos complement binary numeral in which LSB has a weight of 64 feet/minute. However, there are three exceptions:

- The "all ones" coding (binary 11 1111 1111) is reserved to indicate that pressure altitude rate is invalid or not available.
- The most negative of the remaining values (binary 11 1111 1110) is reserved to indicate that the pressure altitude is decreasing at a rate of 32 768 feet per minute or more.
- The most positive of the remaining values (binary 01 1111 1111) is reserved to indicate that the pressure altitude is increasing at a rate of 32 768 feet per minute or more.

Table 2-9 indicates the pressure altitude rate encoding in more detail.

### 2.2.4.1.17 $NAC_V$

The $NAC_V$ (Navigation Accuracy Category for Velocity) is a 4-bit field (byte #18, bits 1-4) that indicates the accuracy of the velocity information. The values of this field are defined in ***draft*** RTCA DO-242A and reproduced in Table 2-10 below.

**Table 2-10. $NAC_V$ Codes**

| $NAC_V$ | Horizontal Velocity Uncertainty (95%) | Vertical Velocity Uncertainty (95%) |
|---|---|---|
| 0 | Unknown | Unknown |
| 1 | < 10 m/s | < 50 feet/second |
| 2 | < 3 m/s | < 15 feet/second |
| 3 | < 1 m/s | < 5 feet/second |
| 4 | < 0.3 m/s | < 1.5 feet/second |

*Note 1: When an internal navigation system is used as the source of velocity information, error in velocity with respect to WGS-84 is reflected in the $NAC_V$ code.*

*Note 2: When any component of velocity is not avialble, the value of $NAC_V$ will apply to the other components that are supplied.*

### 2.2.4.1.18 "T Valid" Flag

The "T Valid" flag is a 1-bit field (byte #18, bit #5) that indicates whether the message transmission was synchronized with the start of a valid MSO (message start opportunity) using the 1 PPS time mark signal from a GPS or other GNSS receiver.

## 2.2.4.2 Type 1 Long ADS-B Message Payload Format and Encoding

Table 2-11 shows the overall format of the payload in the Type 1 Long ADS-B Message. The format of the first 18 bytes in the message is identical to that in the Basic ADS-B Message, described in section 2.2.4.1. . Bytes and bits are transmitted in "big-endian" order; that is, the most significant byte is transmitted first, and within each byte, the most significant bit, bit #1, is transmitted first.

**Table 2-11. Format of Long Type 1 ADS-B Payload.**

| Byte # | Bit 1 | Bit 2 | Bit 3 | Bit 4 | Bit 5 | Bit 6 | Bit 7 | Bit 8 |
|---|---|---|---|---|---|---|---|---|
| 1-18 | | | | **(See Table 2-2)** | | | | |
| 19 | (MSB) | | | **Participant Category Code and** | | | | |
| 20 | | | | **Flight ID (Call Sign) #1 and #2 (Base-40 encoding)** | | | | (LSB) |
| 21 | (MSB) | | | **Flight ID (Call Sign) Characters #3, #4, and #5** | | | | |
| 22 | | | | **(Base-40 Encoding)** | | | | (LSB) |
| 23 | (MSB) | | | **Flight ID (Call Sign) Characters #6, #7, and #8** | | | | |
| 24 | | | | (Base 40 Encoding) | | | | (LSB) |
| 25 | (MSB) | | **Transmission Epoch (6 LSBs of 12-bit MSO #)** | | | (LSB) | (MSB) | |
| 26 | | | | **Geometric Altitude** | | | | |
| 27 | | (LSB) | Status | (MSB) | | **Geometric Altitude Rate** | | |
| 28 | | | | (LSB) | (MSB) | | | |
| 29 | | | | **Capability Class Codes** | | | | (LSB) |
| 30 | **AS Type** | Status | (MSB) | | **AS (Airspeed)** | | | |
| 31 | | | | | (LSB) | **Hdg Valid** | (MSB) | |
| 32 | | | | **Magnetic Heading** | | | | (LSB) |
| 33 | Status | (MSB) | | | **Selected Altitude** | | | |
| 34 | | | (LSB) | | **Emergency/Priority Status** | | | |

### 2.2.4.2.1 Participant Category Code and Call Sign

The participant category code and call sign are encoded as nine base-40 digits, packed, three digits at a time, into three 16-bit fields in the Type 1 Long ADS-B message. The encoding of the participant category and the flight ID characters as base-40 digits are specified in subsection 2.2.4.2.1.1 and 2.2.4.2.1.2 below. The packing of these base-40 digits into the message is described in subsection 2.2.4.2.1.3.

### 2.2.4.2.1.1 Participant Category Code

The participant category code is a 5-bit binary numeral in which the 2 MSBs indicate one of four "participant category sets" and the 3 LSBs specify a particular category within one of those sets. The five-bit category code is regarded as a base-40 digit in the range from 0 to 31.

**<u>Table 2-12</u>. ADS-B Emitter Category Codes**

| Base-40 Digit (Decimal) | Emitter Category | Base-40 Digit (Decimal) | Participant Category | Base-40 Digit (Decimal) | Participant Category |
|---|---|---|---|---|---|
| **Category Set A, Codes 0-7** | | **Category Set C, Codes 16-23** | | **Unused Codes (32-39)** | |
| 0 | No ADS-B emitter category information | 16 | No ADS-B emitter category information | 32 | (Unused) |
| 1 | Light (< 15 500 lbs) | 17 | Sruface Vehicle - Emergency Vehicle | 33 | (Unused) |
| 2 | Small (15 500 to 75 000 lbs) | 18 | Surface Vehicle – Service Vehicle | 34 | (Unused) |
| 3 | Large (75 000 to 300 000 lbs) | 19 | Fixed Ground or Tethered Obstruction | 35 | (Unused) |
| 4 | High Vortex Large (aircraft such as B-757) | 20 | (Reserved) | 36 | (Unused) |
| 5 | Heavy (> 300,000 lbs) | 21 | (Reserved) | 37 | (Unused) |
| 6 | High Performance (> 5 g acceleration and > 400 knots) | 22 | (Reserved) | 38 | (Unused) |
| 7 | Rotorcraft | 23 | (Reserved) | 39 | (Unused) |
| **Category Set B, codes 8-15** | | **Category Set D, Codes 24-31** | | | |
| 8 | No ADS-B emitter category information | 24 | No ADS-B emitter category information | | |
| 9 | Glider or Sailplane | 25 | (Reserved) | | |
| 10 | Lighter-than-Air | 26 | (Reserved) | | |
| 11 | Parachutist / Skydiver | 27 | (Reserved) | | |
| 12 | Ultralight / Hang-glider / Paraglider | 28 | (Reserved) | | |
| 13 | (Reserved) | 29 | (Reserved) | | |
| 14 | Unmanned Aerial Vehicle | 30 | (Reserved) | | |
| 15 | Space / Trans-atmospheric vehicle | 31 | (Reserved) | | |

#### 2.2.4.2.1.2 Flight ID (Call Sign) Characters

The Flight ID consists of eight characters, which must be decimal digits, uppercase letters, or the space character. The 37 possible different characters are represented as base-40 digits in the range from 0 to 36. The first two characters of the Flight ID are packed, together with the participant category code, into bytes 19 and 20 of the Type 1 Long ADS-B message. The next three characters are likewise packed into bytes 21 and 22, and the last three characters into bytes 23 and 24.

Table 2-13 shows the base-40 character coding used for the Flight ID characters.

**Table 2-13. Base-40 Character Code for Flight ID.**

| Base-40 Digit (Decimal) | Character | Base-40 Digit (Decimal) | Character |
|---|---|---|---|
| 0 | 0 | 20 | K |
| 1 | 1 | 21 | L |
| 2 | 2 | 22 | M |
| 3 | 3 | 23 | N |
| 4 | 4 | 24 | O |
| 5 | 5 | 25 | P |
| 6 | 6 | 26 | Q |
| 7 | 7 | 27 | R |
| 8 | 8 | 28 | S |
| 9 | 9 | 29 | T |
| 10 | A | 30 | U |
| 11 | B | 31 | V |
| 12 | C | 32 | W |
| 13 | D | 33 | X |
| 14 | E | 34 | Y |
| 15 | F | 45 | Z |
| 16 | G | 46 | SPACE |
| 17 | H | 47 | (unused) |
| 18 | I | 38 | (unused) |
| 19 | J | 39 | (unused) |

### 2.2.4.2.1.3 Packing Method for Participant Category and Flight ID.

Let C be the base-40 digit representing the participant category code, and let $A_1$, $A_2$, $A_3$, $A_4$, $A_5$, $A_6$, $A_7$, $A_8$ be the base 40 digits representing the eight characters of the Flight ID. Then bytes 19 and 20 of the Type 1 Long ADS-B Message shall hold the binary numeral for the number,

$$C \times 40^2 + A_1 \times 40 + A_2.$$

Likewise, bytes 21 and 22 of the Type 1 Long ADS-B Message shall hold the binary numeral for the number,

$$A_3 \times 40^2 + A_4 \times 40 + A_5$$

and bytes 23 and 24 of the Type 1 Long ADS-B Message shall hold the binary numeral for the number,

$$A_6 \times 40^2 + A_7 \times 40 + A_8.$$

### 2.2.4.2.2 Transmission Epoch

There are 4000 possible MSOs (Message Start Opportunities) in each one-second UAT frame, so the scheduled time of transmission of an ADS-B message may be encoded as a 12-bit binary numeral giving an MSO number in the range from 0 to 3999. In the Type 1 Long ADS-B message, the 6 LSBs of that 12-bit MSO number are encoded into byte #25, bits #1 through #6.

The validity bit for the Transmission Epoch field is the “T Valid” flag (byte #18, bit #5, described in section 2.2.4.1.18 above).

### 2.2.4.2.3 Geometric Altitude

The Geometric Altitude field is a 12-bit field (byte #25, bit #7 through byte #27, bit #2) that encodes the aircraft's height above the WGS-84 ellipsoid. The field is encoded as (altitude + 1000 feet) in 25-foot units. This permits geometric altitudes in the range from -1000 feet to more than +100 000 feet to be encoded in this 12-bit field. The "all ones" coding is reserved to mean "geometric altitude is unavailable or invalid."

```
0 0 0 0 0 0 0 0 0 0 0 0 = -1000 feet
0 0 0 0 0 0 0 0 0 0 0 1 =  -975 feet
. . .
0 0 0 0 0 0 0 0 0 1 1 1 =   -25 feet
0 0 0 0 0 0 1 0 1 0 0 0 =     0 feet
0 0 0 0 0 0 1 0 1 0 0 1 =   +25 feet
. . .
1 1 1 1 1 1 1 1 1 1 1 0 = +101350 feet
1 1 1 1 1 1 1 1 1 1 1 1 =   "invalid geometric altitude" or
                            "geometric  altitude unknown"
```

### 2.2.4.2.4 Geometric Altitude Rate

The Geometric Altitude Rate field and its validity flag are stored in s a 10-bit field (byte #28, bit #5 through byte #29, bit #8). The first bit (byte #27, bit #3) is a validity flag: 1 if a valid geometric altitude rate is available in the remaining bits, 0 if not. The remaining 9 bits (byte 27, bit #4 through byte #28, bit #4) hold the rate of change of geometric altitude, as a signed twos complement binary numeral in which the LSB has a weight of 1 foot per minute.

#### 2.2.4.2.5 Capability Class Codes

The capability class codes are stored as a 12-bit field (byte #28, bit #5 through byte #29, bit #8) in which each bit is a boolean flag indicating whether or not the transmitting aircraft has a certain capability. Table 2-14 lists the capability class code bits. Each bit is 1 if the associated capability is present, 0 otherwise.

**Table 2-14. Capability Class Codes.**

| Byte # | Bit # | Capability |
|---|---|---|
| 28 | 5 | CDTI |
| | 6 | TCAS |
| | 7 | (Reserved) |
| | 8 | (Reserved) |
| 29 | 1 | (Reserved) |
| | 2 | (Reserved) |
| | 3 | (Reserved) |
| | 4 | (Reserved) |
| | 5 | (Reserved) |
| | 6 | (Reserved) |
| | 7 | (Reserved) |
| | 8 | (Reserved) |

#### 2.2.4.2.6 Airspeed

#### 2.2.4.2.7 Magnetic Heading

#### 2.2.4.2.8 Selected Altitude

#### 2.2.4.2.9 Emergency/Priority Status

### 2.2.4.3 Type 2 Long ADS-B Payload Format and Encoding

Table 2-15 shows the overall format of the payload in Type 2 Long ADS-B Message. The format of the first 18 bytes in the message is identical to that in the Basic ADS-B Message, described in section 2.2.4.1. . Bytes and bits are transmitted in "big-endian" order; that is, the most significant byte is transmitted first, and within each byte, the most significant bit, bit #1, is transmitted first.

**Table 2-15. Format of Long Type 2 ADS-B Payload.**

| Byte # | Bit 1 | Bit 2 | Bit 3 | Bit 4 | Bit 5 | Bit 6 | Bit 7 | Bit 8 |
|---|---|---|---|---|---|---|---|---|
| 1-18 | (See Table 2-2) | | | | | | | |
| 19 | | | | | | | | |
| 20 | | | | | | | | |
| 21 | | | | | | | | |
| 22 | | | | | | | | |
| 23 | | | | | | | | |
| 24 | | | | | | | | |
| 25 | | | | | | | | |
| 26 | | | | | | | | |
| 27 | | | | | | | | |
| 28 | | | | | | | | |
| 29 | | | | | | | | |
| 30 | | | | | | | | |
| 31 | | | | | | | | |
| 32 | | | | | | | | |
| 33 | | | | | | | | |
| 34 | | | | | | | | |

[Input needed for this]

### 2.2.4.4 Type 2-14 Supplemental Payload Format and Encoding

These payloads will be addressed in later supplements to this document.

## 2.2.5 Procedures for ADS-B Message Transmission

### 2.2.5.1 The 1 PPS Time Mark

A 1 PPS Time Mark is used by the ADS-B transmitting subsytem to establish the transmission timing and scheduling of ADS-B messages (i.e., the UAT frame) and also may be used to indicate time of validity of position and velocity. The ADS-B transmitting subsystem shall maintain a 1 PPS UTC-based time mark by the reversionary procedure given below:

a. The primary source shall be the GPS/GNSS receiver supplying position, and velocity data. This source shall issue the 1 PPS time mark on the UTC second +/- [300 ns]. Availability of this source shall cause the ADS-B transmitting subsystem to be in Timing State 1. The leading edge of the Time Mark shall indicate the exact moment +/- 5 milliseconds that represents the time of applicability of Position and Velocity information received from the GPS/GNSS source.

b. The secondary source shall be derived from receipt of Ground Uplink messages by the receiving subsystem per Section 2.2.9.3. Lack of availability of the primary source and the availability of this secondary source shall cause the ADS-B transmitting subsystem to be in Timing State 2. The leading edge of the time mark does NOT represent a time of validity of position and velocity. [Is this timing state necessary given the guard times between ADS-B and Ground Uplink Segments? It would not be available to Class B1 installations anyway]

c. The tertiary source shall be derived from a free running clock within the ADS-B transmitting subsystem. Lack of availability of either the primary or secondary source shall cause the ADS-B transmitting subsystem to be in Timing State 3. The leading edge of the time mark does NOT represent a time of validity of position and velocity. ADS-B transmissions shall not encroach on the Ground Uplink segment for at least 1 hour after entry into Timing State 3

*NOTE: Timing State 1 is always the preferred condition. Entry into Timing State 2 or 3 represents a failure of the primary GPS/GNSS navigation source. These reversionary Timing States exist for the following reasons:*

- *support ADS-B message transmission using an alternate source of position and velocity, if available*

- *support ADS-B message transmission in absence of position and velocity data in order that any available fields are conveyed (e.g., baro altitude) and that a signal is provided in the event the ground network can perform an ADS-B-independent localization of the A/V (e.g., multilateration)*

### 2.2.5.2 Scheduling of ADS-B Messages

#### 2.2.5.2.1 Message Transmission Epoch

ADS-B message transmissions shall be scheduled based on a message transmission epoch composed of exactly four UAT frame intervals.

*NOTE: There is no requirement that transmission epoch boundaries be aligned amongst A/Vs; it is used only to ensure proper mix of transmitted message types.*

### 2.2.5.2.2 Message Transmission Rate

The message scheduling mechanism shall provide the message transmission rates specified in Table X below based on the availability of data to the ADS-B transmitting subsystem.

**ADS-B Message Contents and Transmission Rates**

| | | | | Transmission Rate per Epoch | | | |
|---|---|---|---|---|---|---|---|
| **Message Type** | **Payload Type Code** | **Message Length** | **Contents** | All Class B2 (non-aircraft transmitters) | Standard Info Bdcst for All Class A0, A1, B1 | Standard info Bdcst for Class A2, A3 | <Future Applications> |
| Basic | 0000 | Short | SV *only* | 4 | 3 | 1 | |
| Extended Type 1 | 0001 | Long | SV *plus* Supplemental Type 0 payload | | 1 | 1 | |
| Extended Type 2 | 0010 | Long | SV *plus* Supplemental Type 1 payload | | | 2 | |
| Extended Type 3-11 | 0011-1011 | Long | SV plus Supplemental externally supplied payload (128 bits) provided "on condition" each epoch | | | | |
| Typed 12-15 | 11XXX | TBD | TBD | | | | |

### 2.2.5.2.3 Transmitter Antenna Diversity

For installations that support ADS-B message transmission from dual (diversity) antennas, the installation shall be configured to transmit through each antenna at one half the rate specified in Section 2.2.5.2.2:

a. On a total message basis per epoch, and

b. Such that each message type scheduled is transmitted from both antennas at least once every two transmission epochs

*NOTE: Antenna diversity could be implemented with dual redundant transmitters each connected to its dedicated antenna or from a single transmitter with antenna switching.*

### 2.2.5.2.4 Unavailability of Basic SV Message Payload Fields

a. In any UAT frame interval, each A/V shall at a minimum transmit the Basic ADS-B message regardless of the unavailability of any individual payload field.

b. Any such unavailable payload fields shall be encoded as "unavailable"

### 2.2.5.3 Message Transmit Timing

### 2.2.5.3.1 The Message Start Opportunity (MSO)

ADS-B bursts shall be transmitted at discrete Message Start Opportunities (MSO) chosen by a pseudo-random process. The specific pseudo-random number chosen by an aircraft depends on the aircraft's current position and on the previously chosen random number. The procedure below shall be employed to establish the transmission timing for the current UAT frame *m*.

The desired output of the algorithm is a 12-bit pseudorandom number. Suppose the previous number is R(m-1) and

N(1) = 12 L.S.B.'s of the current latitude

N(2) = 12 L.S.B.'s of the current longitude

where the latitude and longitude are as defined in Section 2.2.4.1.2 and 2.2.4.1.3 respectively. The next random number is then given by

$$R(m) = \{4001 \cdot R(m-1) + N(m \bmod 2)\} \bmod 3200$$

The initial R(m) shall be zero

*NOTE: The latitude and longitude alternate in providing a changing "seed" for the pseudo-random number generation.*

*NOTE: This algorithm provides anonymity to the aircraft and ensures, with very high probability, that no two aircraft will repeatedly choose the same MSO's.*

### 2.2.5.3.2 Relationship of the MSO to the Modulated Data

The leading edge of the first baud of the synchronization sequence shall coincide with the Time Mark offset by 250 usec times the MSO value determined from Section 2.2.5.3.1 to within +/- [250 nanoseconds].

*NOTE: This is required to support ADS-B range validation by the receiver*

### 2.2.5.4 Latency of ADS-B Message Payload Fields

#### 2.2.5.4.1 UTC Coupled and Non-UTC Coupled Cases for Position and Velocity

The specification of latency requirements for position and velocity cover two distinct cases:

a. The UTC Coupled case is the condition where the position and velocity data are computed and valid at the 1 PPS UTC time mark also provided by the same navigation system. This case will also correspond to the ADS-B transmitting subsystem being in Timing State 1

b. The Non-UTC Coupled case is the condition where position and velocity data come from an alternate navigation source (non-GPS/GNSS) where UTC time is not available. This case will correspond to the ADS-B transmitting subsystem being in Timing State 2 or 3

#### 2.2.5.4.2 Position and Velocity (UTC Coupled, Timing State 1)

At the time of ADS-B message transmission as determined in Section 2.2.5.3.1, position and velocity information encoded in the Latitude, Longitude, N-S Velocity, and E-W Velocity fields shall be valid as of the immediately previous 1 PPS Time Mark. Specifically, NO extrapolation to the time of transmission is to be performed.

#### 2.2.5.4.3 Position and Velocity (Non-UTC Coupled)

[To be provided]

#### 2.2.5.4.4 Other Message Payload Fields (UTC or Non-UTC Coupled)

Any change in information affecting the ADS-B message payload fields shall be reflected in the encoding of that field, provided that the change occurs and is available to the ADS-B transmitting subsystem within at least ***X*** milliseconds prior to the next scheduled ADS-B message containing that field. Table 2-15 below shows the value of ***X*** for each field.

**Latency of ADS-B Message Fields**

| ADS-B Message Payload Field | Value of X (Section 2.2.5.4.4) |
|---|---|
| 25-Bit UAT Address | 1000 |
| Latitude | Section 2.2.5.4.2 and 2.2.5.4.3 applies |
| Longitude | Section 2.2.5.4.2 and 2.2.5.4.3 applies |
| NUCp | 100 |
| Turn Indicator | 100 |
| Horizontal Pos Available | 100 |
| UTC Coupled | 100 |
| N-S Velocity | Section 2.2.5.4.2 and 2.2.5.4.3 applies |
| E-W Velocity | Section 2.2.5.4.2 and 2.2.5.4.3 applies |
| Pressure Altitude | 100 |
| Pressure Altitude Rate | 100 |
| A/G State | 100 |
| Geodetic Height Difference | 100 |
| Height Valid | 100 |
| Emergency/Priority Status | 100 |
| Geodetic Height Difference Rate | 100 |
| Aircraft Category subfield | Not changable |
| Flight ID subfield | 1000 |
| Message Start Opportunity | Must use value established by ADS-B transmitting subsystem for the current frame |

## 2.2.6 Receiver Characteristics

### 2.2.6.1 Sensitivity

A maximum desired signal level of –93 dBm applied at the antenna terminals shall produce a message success rate of 90% or better.

### 2.2.6.2 Frequency Capture Range

The receiver shall be capable of successful message detection with the maximum permitted signal frequency offset plus air-air doppler at 1200 knots closure/opening.

### 2.2.6.3 Baud Rate Offset Tolerance

A 90% message success rate shall be achieved when the desired signal is subject to a symbol rate offset of +/-100 ppm.

#### 2.2.6.4 Desired Signal Dynamic Range

The receiver shall continue to achieve a 90% message success rate when the desired signal level is increased to [-10 dBm].

#### 2.2.6.5 Back-to-Back Message Reception

[Test to establish minimum receiver recovery time. How to specify and test? Is it important? Is a separate requirement necessary for ADS-B and Ground Uplink?]

#### 2.2.6.6 Amplitude Discrimination of Overlapping ADS-B Messages

A 90% or better message success rate for the stronger of two overlapping desired signals shall result when the level of the stronger signal is at –80 dBm and the stronger signal is [6 dB] above the weaker signal under the following conditions:

a. the stronger signal and weaker signal align within +/- 5 usec

b. the weaker signal precedes the stronger signal by 100 usec

#### 2.2.6.7 Rejection of Out-of-Band Signals

A 90% message success rate shall be achieved when an unmodulated continuous wave interfering signal of [-30 dBm] is combined with the desired signal at –70 dBm. The interfering signal shall be applied separately + 2 and – 2 MHz offset from $f_0$.

*NOTE: This establishes the receiver's rejection of off channel energy radiated from DME ground stations adjacent to the UAT guard band.*

#### 2.2.6.8 Tolerance to Pulsed Interference

[Test to verify FEC operation and receiver recovery time from high level on channel interfering pulse at around –40 dBm when detecting signal near sensitivity. Test should allow for random pulse placement across the message]

#### 2.2.6.9 Message Time of Receipt

The receiver shall declare a Message Time Of Receipt (MTOR) and include the MTOR value as part of the report issued to the on-board application systems. The MTOR value shall be reported to within [+/- 200 nanoseconds] of the actual value with 95% confidence.

*NOTE: The MTOR value need only be expressed in terms of offset from the 1 PPS UTC time mark just prior to reception.*

### 2.2.6.10 Receiver Discrimination Between ADS-B and Ground Uplink Message Types

The receiver shall NOT infer message type for decoding based on its location within the UAT frame.

*NOTE: The polarity of the correlation score from the synchronization process is available for this purpose*

## 2.2.7 Report Generation Requirements

Reports shall be generated for on-board applications only in response to a received message. Exactly one report shall be generated for each message successfully received.

### 2.2.7.1 Report Generation on Receipt of ADS-B Message

#### 2.2.7.1.1 Message Integrity Requirements

No ADS-B message payload shall be forwarded as a report unless the decoding of the CRC parity and FEC parity EACH indicate that there are NO detected errors.

#### 2.2.7.1.2 Report Generation and Integrity

a. Upon receipt of an ADS-B message with no detected errors, a report shall be issued that includes the unaltered payload of the message received and the MTOR (Section 2.2.6.9).

b. Reports shall be issued from the UAT receiver to on-board application systems with an integrity check at least equivalent to a CRC-16.

### 2.2.7.2 Report Generation on Receipt of Ground Uplink Message

#### 2.2.7.2.1 Message Integrity Requirements

a. Each R/S block of the Ground Uplink message shall be individually examined for errors. The payload of each block shall be declared as valid only if there are NO detected errors resulting from FEC Parity decoding.

b. The Ground Uplink message shall be declared as valid only if payloads within EACH individiual R/S Block are declared valid from a) above.

#### 2.2.7.2.2 Report Generation and Integrity

If the requirements of Section 2.2.7.2.1 are met, the Ground Uplink Message payload is created with the steps described below:

a. The individual R/S block payloads are concatenated in the order received.

b. A report shall be issued that includes the unaltered payload of the message received and the MTOR (Section 2.2.6.9).

a. Reports shall be issued from the UAT receiver to on-board application systems with an integrity check at least equivalent to a CRC-16

### 2.2.8 Receiver Subsystem Throughput Requirements

#### 2.2.8.1 Input Message Capacity

[What total ADS-B and Gnd Uplink load is reasonable in full NAS environment?]

#### 2.2.8.2 Output Report Latency

[Need reasonable number for latency from message arrival at rx antenna to issuance of report under the load established for 2.2.8.1. Appendix K of DO-242 allows up to 100 ms for "report assembly"]

### 2.2.9 Special Requirements for Transceiver Implementations

#### 2.2.9.1 Transmit-Receive Turnaround Time

The receiver shall be capable of receiving a desired signal within [2] ms of the ramp down of a transmitted signal.

#### 2.2.9.2 Receive-Transmit Turnaround Time

The transmitter shall be capable of commencing transmission of an ADS-B message within [2] ms after arrival of a successfully received desired signal

#### 2.2.9.3 Estimated 1 PPS

In the absence of an external 1 PPS UTC time mark, the receiver shall provide a 1 PPS UTC estimated time mark to the transmitter when at least one Ground Uplink message is received per UAT frame. This estimated time mark shall be sufficiently accurate to prevent ADS-B message transmissions from straying outside the ADS-B segment as long as the Ground Uplink messages are being received.

[When should this be a requirement?  It seems this capability matters only if the installation supports an alternate navigation input to ADS-B]